Reducing Forage Producers' Drought Vulnerability in the Southeastern USA

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Sector Applications Research Program – SARP

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Clyde W. Fraisse

Agricultural and Biological Engineering

University of Florida

Abstract

Drought conditions are a frequent occurrence in the Southeast and 2007 has not been different. In fact the severe drought has created a pasture and hay shortage throughout the region, greatly impacting farm finances and profit. In the Coastal Plain of Georgia, the Florida Panhandle, and the Northeast Central and Southwest regions of Florida, pasture conditions were mostly very poor and hay supply was exhausted at the initiation of summer. Last year hay production (ton/acre) for Florida was record low for the past 20-years. Most cattlemen were forced to feed supplemental hay and grain. Hay farmers are also experiencing high fertilizer prices, with little chance to recover input costs. Many producers, as part of the recommended practices to cope with drought, were weaning early or selling off some animals to decrease their stocking rate, with average weight at sale down in many areas. According to the University of Georgia Center for Agribusiness and Economic Development, drought conditions that have persisted throughout 2007 have caused losses of $787.2 million in production losses to Georgia's agricultural sector. Pasture losses are $264.7 million of grass for grazing. Hay losses of $83.8 million are 59% of normal production value. Based on our experience developing decision support systems to help producers mitigate production risks associated with climate variability, we will develop a decision support system specifically designed to help forage producers cope and adapt to drought conditions in the southeastern USA. A simple, yet reliable water deficit index will be monitored and forecast based on weather data collected by weather networks in Florida and Georgia, short term weather forecast provided by the NWS, and ENSO phases. The system will also include suggested management options for current and anticipated drought conditions and developed with intensive stakeholder participation. Training workshops and outreach events will be conducted to train extension faculty and producers in the use tools developed under this project. Venues will include field days, extension staff training, and regional meetings of producer associations.

1. Activities conducted during the reporting time (September 2008 – March 2009)

Activities during this period focused primarily on Objective 2 of the proposed study (*Develop a water deficit index and validate in producer's fields*):

1. Evaluation of the proposed algorithm to estimate a drought index using data collected in an existing weather station located in the Citra research farm, University of Florida.
2. Installation of soil moisture probes and soil moisture monitoring in a cooperators field located in Bronson, Levy County, Florida.

1.1 Determination of Drought Index using existing data collected at the University of Florida IFAS Citra Research Farm

Our proposed Agricultural Reference Drought Index (ARID) was evaluated by comparing observed and estimated soil moisture content for a period of about 400 days during 2007 and 2008. Data collected at the University of Florida Plant Science Research and Education Unit (PSREU), located near Citra, Florida, included soil moisture at various depths and all weather variables required for ARID calculation such as precipitation, solar radiation, temperature, relative humidity, and wind speed (Fig. 1). Precipitation data at the weather station were collected with a tipping bucket rain gauge. Volumetric soil moisture content was recorded every 15 min using time domain reflectometry (TDR) sensors (CS616 Water Content Reflectometer, Campbell Scientific, Logan, UT). Measurements made with the TDR probes are accurate up to +/-2.5% VWC (Campbell Scientific, Inc., 2007). These sensors were connected to a CR-10X datalogger. The TDR sensors were buried close to the weather station at a depth of 15 and 30 cm. The soil has been classified as Candler sand with 97% sand-sized particles in the upper 1 m of the profile (Carlisle et al., 1988).

Figure 1. Weather station at the UF research center located in PSREU, Citra, FL.

A good agreement was found between the index-predicted and field-observed soil moisture contents (d-index = 0.90) (Fig. 2). The RMSE value was 0.014, and the prediction error was of 10%. These statistics indicate that soil moisture contents simulated by the soil water balance approach agrees well with field conditions and ARID is a good indicator of plant water stress levels.

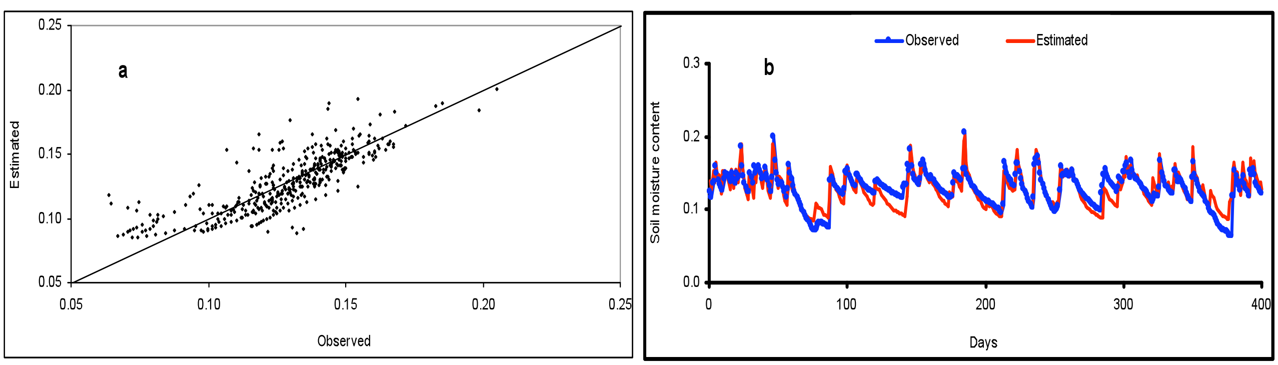

Figure 2. a): The agreement of ARID-estimated and field observed volumetric soil moisture contents; and b): daily time series values of observed and estimated soil moisture content (30 cm) over a period of one year between 2007 and 2008.

Figure 3a shows values of average soil moisture content, precipitation, and ARID daily values. Figure 3b shows ARID and soil moisture content and demonstrates that lower soil moisture contents correspond to higher ARID values.

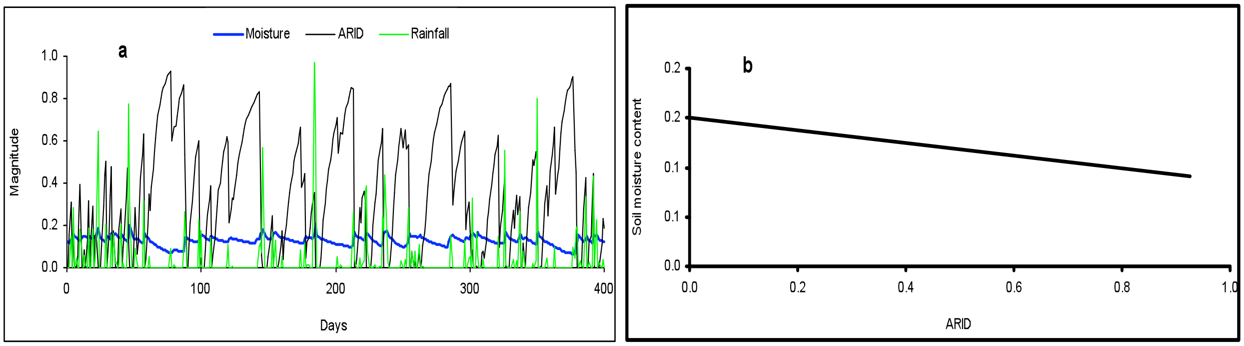

Figure 3. a): The time series of soil moisture content, ARID, and normalized rainfall; and b) the relationship of ARID and soil moisture content.

These results indicate that ARID is a good indicator of soil moisture content and can therefore be used to indicate plant water stress levels. We plan to use these results when discussing with producers the opportunities use ARID in their decision making process.

1.2 Soil moisture and biomass production monitoring at Quincey Farm, Bronson, Florida

During the fall of 2008 we started monitoring soil moisture and biomass production in an established Tifton 85 hay field in a commercial cattle farm near Chiefland, Levy County, within the Suwannee River basin in north central Florida (29°30'37.38"N , 82°48'49.04"W). Soils are classified in Otela-Candler complex; that corresponds to moderately to excessively well drained fine sands (Loamy, siliceous, semiactive, thermic Grossarenic Paleudalfs) characterized by a rapid permeability, slow surface runoff, water table below a depth of 1.4 m, and gently rolling topography (Soil Service Staff, 2009). In terms of climate, the site presents typical north-central Florida temperature and precipitation patters. Spring and fall periods tend to be relatively dry (55-100mm), with mean temperatures ranging between 17 and 21°C; summers show precipitation levels between 130 and 200mm, with high mean temperatures (24 to 27 °C); while winters are relatively mild (12-15°C), with rainfall ranging between 55 and 95 mm. Precipitation in 2008 was considerably lower than the 51 year average (1030.5 and 1525.2 mm, respectively), reflected in markedly drier April-July and September-December periods. Our goal is to use this site for demonstration and interaction with cattle ranchers in north central Florida.

Two plots that have been used for biomass sampling every 27 days (typical harvest frequency used by hay producers) but maintained at different heights, tall stubble (6 inches) and short stubble (3 inches) were selected for soil moisture monitoring. Time domain reflectometry (TDR) probes (CS-616, Campbell Scientific, Inc. Logan, Utah) connected to a datalogger (CR-10X, Campbell Scientific, Inc., Logan, Utah) were installed on 10 September, 2008 at 5 depths, 5; 15; 30; 45 and 60 cm in each plot (Figure 1). The soil moisture reading intervals are 15 minutes.

During TDR probe installation, soil bulk density was determined by cylindrical metal ring (136.7 cm^3). A cylindrical metal sampler was driven into the soil carefully removed to preserve a known volume of sample as it existed *in situ*. Samples were taken from the 5-10, 10-20 and 20-30 cm depths. The total sample (approximately 200-210 grams) was stored in a plastic bag and sealed. Samples were placed in oven at 105 ºC for a minimum of 24 hours for drying, and then weighed again to obtain the dry weight. Soil bulk density was determined dividing the soil dry weight for each cylinder by the volume of the correspondent cylinder. The results were expressed in g cm^{-3}.

Figure 3. Installation of TDR probes at Quincey Farm.

An automatic rain gauge (Campbell Scientific, Inc., Logan, Utah) was also installed and the precipitation *in situ* were recorded every 15 min. Additional weather data necessary for estimating the proposed drought index (temperature, wind speed) are retrieved from the closest Florida Automated Weather Network (FAWN) located in Bronson, Florida, approximately 7 miles from the field.

Initial Results

Measured values of soil bulk density were 1.53±0.02; 1.62±0.03 and 1.62±0.04 g cm^{-3} for 0-10; 10-20 and 20-30 cm depths, respectively. These values are in the expected range of soil bulk density for the soil type and pasture management practices.

Figures 4 through 7 illustrate soil moisture content as measured by TDR probes and the occurrence of rainfall during the fall season of 2008. After each rainfall event, there is a noticeable increase in soil moisture content. The degree to which the soil moisture content increases, however, is dependent upon the precipitation. For example, on September 17, a rainfall of 2 mm result in a minor increase in soil moisture, which was observed only at 5 and 15 cm depth (Fig. 4 and 6). However, the rainfall event on September 21 (9.9 mm) resulted in water percolation through the soil profile and noticeable increase in soil moisture in deeper soil layers (below 45 cm depth). The effect of high intensity rainfall and low intensity rainfall can be observed comparing the soil moisture spikes after rainfall occurred on September 21 (9.9 mm) and October 23, 24 and 25 (6.6 mm). The high intensity rainfall on September 21 quickly wetted the entire profile. These rapid spikes in soil water content indicates that the soil water content as measured by the TDR probes rapidly reaches a point above the soil water holding capacity and water starts to percolate down to deeper soil layers, resulting in excessive water percolation and consequent nutrient leaching. The rainfall events in October 23 and 24 amounted to 6 mm but soil moisture increases were only observed at 5, 15 and 30 cm depths, indicating that deep percolation did not occur.

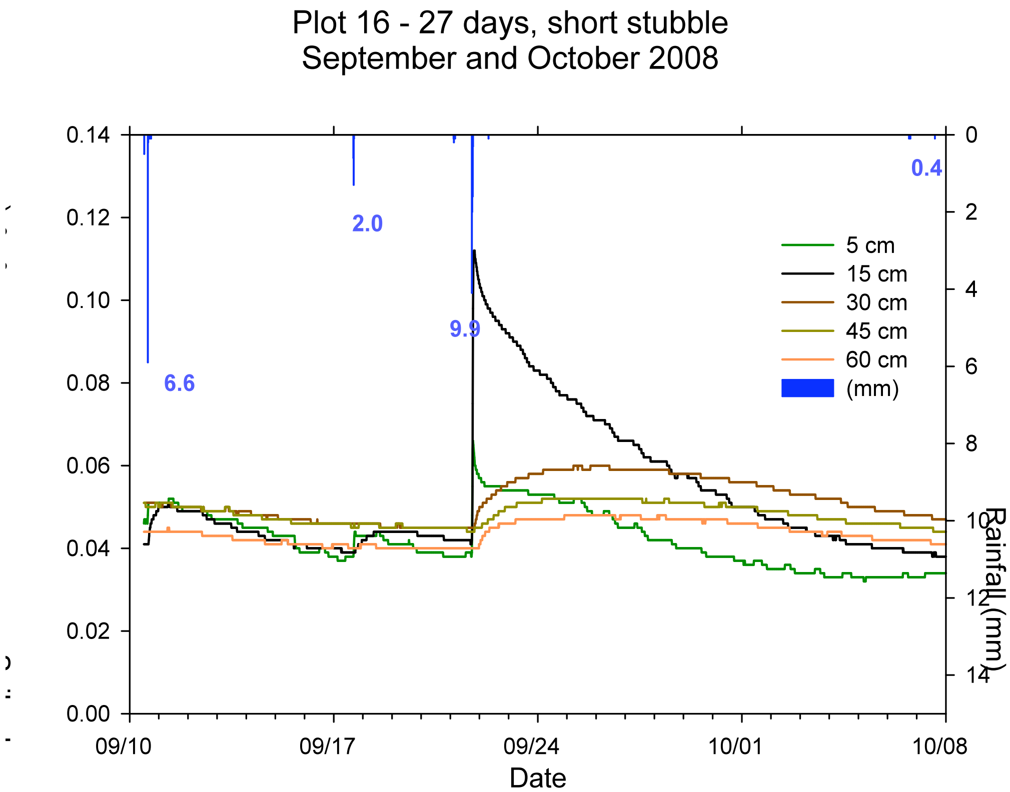

Figure. 4. Volumetric water content (VWC) measured at 5, 15, 30, 45, and 60 cm for September 10 to October 8 2008 (short stubble, 27 days interval). Rainfall events are represented by blue bars.

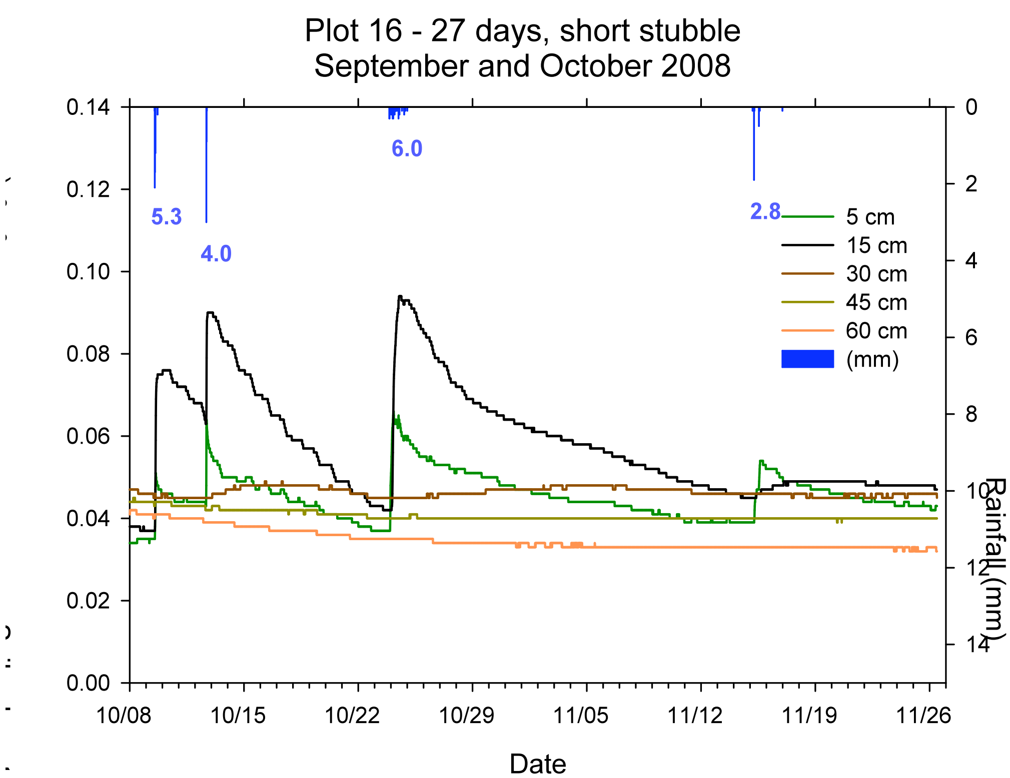

Figure 5. Volumetric water content (VWC) measured at 5, 15, 30, 45, and 60 cm from October 8 2008 to November 27 2008 at PLOT 16 (short stubble, 27 days interval).

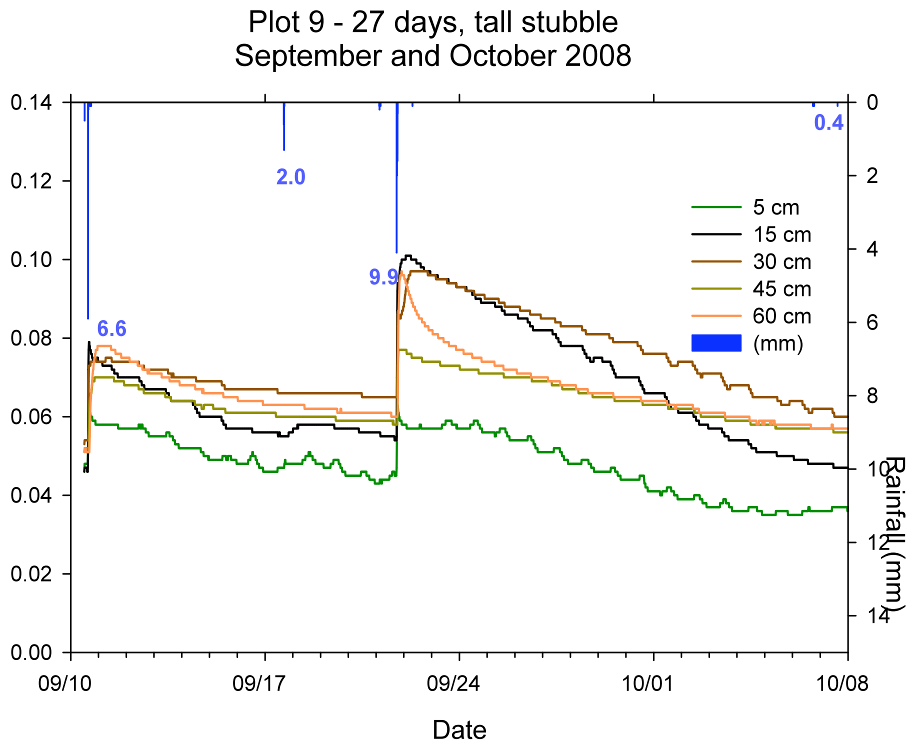

Figure 6. Volumetric water content (VWC) measured at 5, 15, 30, 45, and 60 cm from September 10 to October 8 2008 at PLOT 9 (tall stubble, 27 days interval).

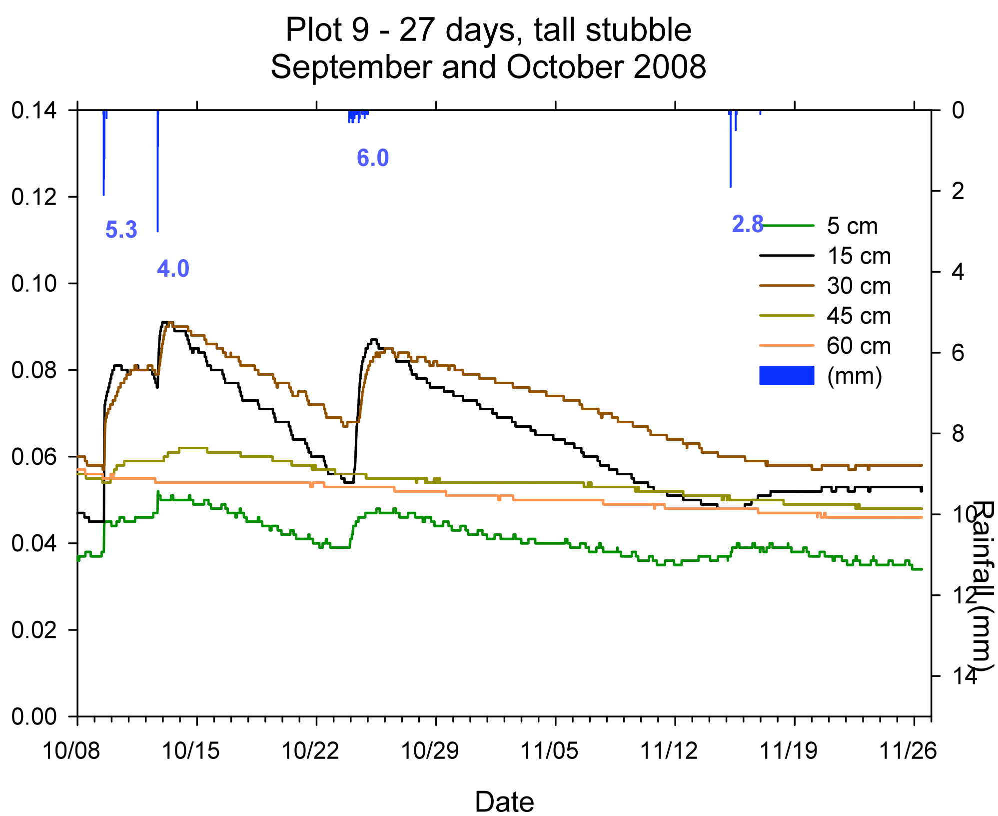

Figure 7. Volumetric water content (VWC) measured at 5, 15, 30, 45, and 60 cm from October 8 2008 to November 27 2008 at PLOT 9 (tall stubble, 27 days interval).

2.0 Plans for 2009

During the next reporting period we intend to expand soil moisture monitoring activities and focus on the assessment of forage producer needs (Objective 1). Although assessment activities were suppose to start in the first 6 months of the project, we decided that having initial results of soil moisture monitoring activities together with drought index estimations would facilitate discussions with producers and generate more effective feedbacks. Regarding the expansion of soil moisture monitoring activities, we will instrument one field in Georgia and two additional sites in Florida. In Florida we will instrument an additional bahiagrass-monitoring site that includes irrigated and non-irrigated plots at the University of Florida PSREU. Second, we will install instrumentation in a cooperators field (Buck Island Ranch) that is located in South Florida and may add an interesting perspective since the region is subject to high water table conditions.

2.1 Soil moisture monitoring and bahiagrass biomass production at PSREU, Citra, Florida

In March of 2009, a field experiment was established at the University of Florida, Plant Science Research and Education Unit, near Citra, FL. This area will be monitored under rain fed and irrigated conditions. Our objective is to achieve the potential plant biomass production (under irrigated and fertilized treatments) and contrast it with regular practices conditions found in Florida (non irrigated). The experimental area consisted in a homogeneous 2-yr old established pasture of bahiagrass (Fig. 8). Soil samples of the 0-30 cm soil layer were taken and analyzed for macronutrients, and the fertilizer rate was determined according to the Institute of Food and Agriculture Sciences (IFAS) recommendation. Two irrigation treatments (irrigated and non-irrigated) and two fertilizer treatments (fertilized and

non-fertilized) were established in a split plot design. Each treatment was located in a square area of 1090 m^2. The irrigation will be applied at a fixed rate of 17-19 mm per application twice a week (Mondays and Thursdays), and the application will be skipped when if a rainfall event greater of 25 mm occur in the previous to the scheduled irrigation event. The fertilizer will be applied to the fertilized treatments monthly at a rate of 96 kg of N ha^{-1} and 48 kg of K ha^{-1}. Plant biomass accumulation will be evaluated by harvesting four representative areas of 1.0 m^2 per treatment every 28 days. Plant tissue will be dried at 65 ^{o}C for subsequent dry weight determination. Time domain reflectometry (TDR) probes (CS-616, Campbell Scientific, Inc. Logan, Utah) connected to a datalogger (CR-10X, Campbell Scientific, Inc., Logan, Utah) will be installed in end of April of 2009 at 5 depths, 5; 15; 30; 45 and 60 cm in each plot (Fig. 9). The soil moisture reading intervals will be 15 minutes.

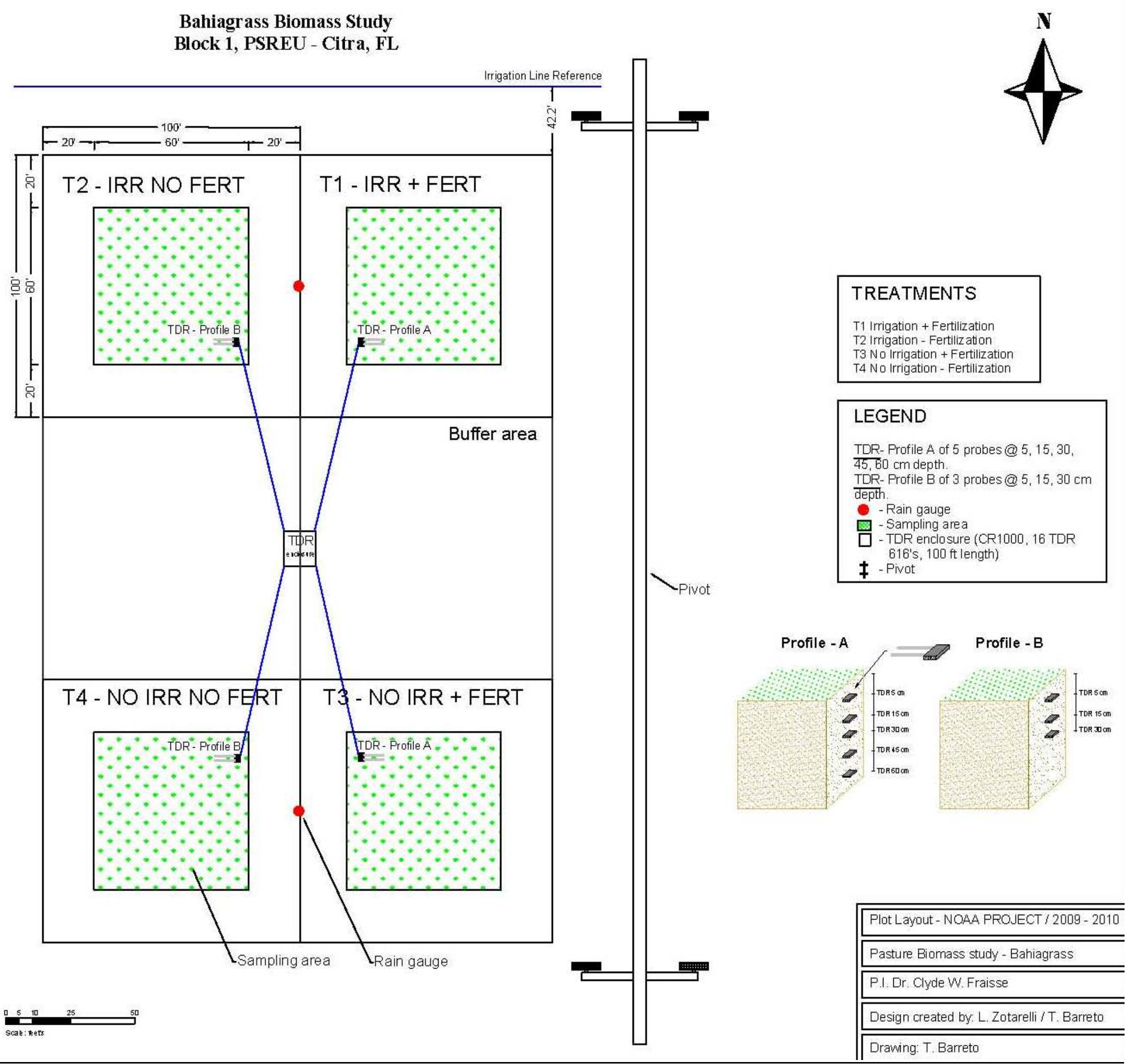

Figure 9. Plot map of bahiagrass biomass production experiment at PSREU, Citra, FL.

References

Carlisle, V.W., Sodek III, F., Collins, M.E., Hammond, L.C., Harris, W.G., 1988. Characterization data for selected Florida soils. University of Florida-Institute of Food and Agricultural Sciences. Soil Sci. Res. Report . Gainesville, FL. 88-1.